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Managing Pine Forests to Improve Water Quality

George E. Dissmeyer 1/

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ABSTRACT - The Federal Water Pollution Act Amendments of 1972 have potentially important impacts on managing pine forests. These Amendments are expected to require management to apply the best available technology to control pollution from forestry practices. Forestry practices used during a rotation of pine on Piedmont and Coastal Plain soils are discussed as to their potential contribution to suspended sediment. The type of management philosophy needed to meet the requirements of the law is presented.

INTRODUCTION

Since the Federal Water Pollution Control Act Amendments of 1972 were enacted, interest in water pollution control on forest lands has gained momentum. The Environmental Protection Agency has published a report entitled "Processes, Procedures, and Methods to Control Pollution resulting from Silvicultural Activities, which has caused much discussion. EPA has initiated several new contract studies to examine the nature and extent of pollution from forest land. For example, Midwest Research Institue has a contract to determine how much pollution comes from silvicultural practices and to develop methods for predicting such pollution. Another contract has been let to determine which existing laws can be used to control pollution. In addition, the agency has a pilot control project in the Northwest to develop the control methodology for pollution from forest lands. The U. S. Forest Service and EPA are working out an agreement through which the Forest Service would provide a state-of-art document on guidelines, procedures and predictive models to determine water pollution loadings from forested watersheds. According to its 1974 Strategy Paper, EPA expects to implement plans to control pollution from forest lands in 1978.

Understandably, foresters are becoming more and more concerned about the potential effects of federal water pollution regulations and resulting State legislation on forest management. Therefore, this paper has a two fold purpose: (1) to explore what is known about the impacts of present forest management on water quality, and (2) to present a management philosophy needed to meet water quality regulations.

1/ Hydrologist, Resource Use and Management, Southeastern Area, USDA Forest Service, Atlanta, Georgia.

IMPACTS OF PRESENT FOREST PRACTICES

What are the water quality impacts of forest land uses and management practices? The U. S. Forest Service held a Water Quality Surveillance Workshop in Denver, Colorado in May 1973. As a product of this workshop, the agency's water quality experts produced a matrix of cause-effect relations between forest management practices and water quality parameters, ranking the impacts by importance (Figure 1). The purpose of the matrix was to provide a guide for water quality monitoring of land management activities.

The parameter consistently ranked as the most important is suspended sediment or turbidity, which is most often affected over a timber rotation. Therefore, as an exercise, consider several rotations where management includes mechanical site preparation, planting, prescribed burns, thinning and the harvest cut. Assume every acre is under management and experiences all activities.

The conditions used are average conditions found in field surveys for river basin studies. The impact of an activity or piece of equipment depends on the man-on-the-ground or equipment operator. Nevertheless, for this exercise, we will concentrate on the concepts rather than the values used. The exercise and its values are used to illustrate a management philosophy necessary to meet the requirements of water quality laws.

First to be examined are the activities under consideration. Mechanical site preparation is done with a KG blade and the debris is windrowed exposing 85 percent of the soil. The prepared area is machine planted and the resultant plantation stabilizes the area in four years. During the rotation, there are several prescribed burns to control hardwood competition. Thinnings are made, and finally, the harvest cut removes the stand leaving a few spur roads and skid trails. Then the cycle starts anew.

When considering managing young pines, one automatically thinks of the Flatwoods, the Coastal Plain and the Piedmont. This example will be limited to the Coastal Plain and Piedmont, because the site preparation described is more characteristically found in these land resource areas than in the Flatwoods. Also, the Flatwoods are so flat that little, if any, erosion occurs.

The question becomes, what are the impacts of these practices on suspended sediment? For this exercise, approximations of the suspended sediment impacts for the described series of activities are made using Santee River Basin data and a procedure called First Approximation of Suspended Sediment, or FASS (Dissmeyer, 1973). The values presented are based upon a reconnaissance field survey where erosion and hydrology data were collected in the Santee River Basin. Therefore, the values are presented for two purposes: (1) to illustrate the possible magnitude of suspended sediment impacts, (Table 1) and, (2) to compare the approximated water quality with EPA's proposed standard for suspended solids of 80 PPM (EPA, 1973).

The table illustrates several points. First, prevailing forest management practices can cause the impairment of water quality far in excess of the proposed standard. Second, the most important impacts are site preparation

and prescribed fire. Third, logging has a nominal impact because most of the litter is left in place and only a small proportion of the area is left in skid trails and spur roads. Finally, as the rotation ages increase, impacts are reduced because disturbances become less frequent and occupy a smaller proportion of the area, therefore, yielding less sediment.

Of course, this is an example of impact on suspended sediment, but it shows what might happen if we are not concerned with water quality impacts. In the real world, not every acre to be planted is site prepared using KG Blade and windrowing. Some areas are planted without preparation and in many instances, less severe soil disturbing treatments are used. Also, forest access roads can be important sources of sediment and need sediment control treatments, but in this example we are limiting our thoughts to stand management. Let's continue with this example to show how to reduce suspended sediment impacts and to meet the expected requirements of water quality laws.

MANAGEMENT PHILOSOPHY NEEDED TO MEET LEGAL REQUIREMENTS

The philosophy needed is that management select the series of management practices that will have as a composit, the least impact upon water quality. The reason for this philosophy can be interpreted from the Federal Water Pollution Control Act Amendments of 1972. For industrial pollution, the best practical control technology is to be applied by 1977, best available by 1983, and no discharge by 1985. The later goal is deemed as probably impractical and even possibly undesirable by EPA (1974). Further evidence is that the model erosion control law, that the National Association of Conservation Districts and EPA are sponsoring, states that if a farmer has an approved farm plan and is following it, he has met the requirements of the erosion control law. This plan is an expression of best available technology in farm management. Other evidence exists but there is a fraction in the country that is pressing for the rigid compliance with water quality standards and a permit system for many land uses and types of land management practices. Today, no one is absolutely sure what is going to be required. However, based upon present trends, it is probably safe to assume that best available technology will meet the requirements of the law. Therefore, we will explore what would be involved in applying the best available technology in managing pine forests and compare the resultant suspended sediment with the EPA's proposed standard of 80 ppm.

This standard is undefined as to how to apply. The proposed standard does not state whether it is an average annual concentration, a maximum not to be exceeded at any time, etc. Also, the standard does not define the point of measurement. Does it apply to a gage on stream draining a large forested watershed under sustained yield management, or does it apply to a creek draining a logged area, etc. It is difficult to visualize the monitoring of water from every land management activity. Also, fish can stand short periods of higher turbidity. Therefore, it is assumed for this exercise that the standard is an average annual concentration for a stream draining a forested watershed under sustained yield management.

Over a pine rotation, several management practices are applied - site preparation, prescribed burns, thinnings and the harvest cut. The problem becomes

selecting the combination of practices that, when applied with water quality values in mind, produce the highest quality of water and yet meets the timber needs.

In our exercise, mechanical site preparation and fire are the most important sources of sediment. There is a relationship between the frequency of burns and the type of mechanical site preparation needed for regeneration. Usually, frequent burns result in hardwood understories that are light in density and small in stem size, which can be treated with a drum chopper. The absence of prescribed burning allows the hardwoods to form a dense understory with larger stems which probably would require KG blading, windrowing and burning, or some other intensive site disturbing treatment.

This leads to a trade-off between air quality and water quality, because chopping causes much less erosion than KG blade work. However, chopping requires more frequent burning to keep material small enough for the chopper. This leads to management decisions based upon which one of the environmental quality factors (air or water) is most important for the region in which the forest occurs.

Let's assume we are more concerned with water quality and want to use the site preparation treatment that yields the least amount of sediment. In Southeastern river basins, the Forest Service has sampled several types of mechanical site preparation treatments for erosion and sediment production. Based upon our data, chopping is the best, although there may be better ones we have not sampled. Therefore, let's say we are going to switch from KG blade, windrowing and burning to chopping. Why? Because chopping experiences: (1) about one-fifth (0.2) the erosion; (2) about a tenth (0.1) of the sediment delivery ratio; and (3) heals in half (0.5) the time as does KG prepared areas.

Under present conditions, not all mechanical site preparation areas have an adequate filter strip between the treated area and the stream. Therefore, we will assume that half (0.5) of the mechanical site prepared areas do not have an adequate filter strip and we are going to install them using the guidelines established by the U. S. Forest Service in its Appalachian Management criteria. These guidelines assume that the filter is 90 percent (0.9) effective in trapping sediment. Thus, from our data and assumptions, by switching to chopping and combining the effect of filter strips should reduce suspended sediment by approximately 1.0-(.2x.1x.5x.5x.9) or 99.55 percent. Therefore, using chopping and leaving filter strips should reduce the sediment yield from mechanical site preparation to approximately 5,3,2 and 2 ppm for 20,30,40, and 60-year rotations is computed (Table 2).

To control hardwoods and keep their stem diameters small requires burning every 5 to 7 years (Langdon, 1971). Therefore, the number of burns would increase to 3,4,6, and 9 for rotations of 20,30,40, and 60, respectively (Table 2). Because we are applying the best methods for pollution control, these burns will be light (just hot enough to control hardwoods). Such burns should consume little more than last year's needle cast, heal in two years and have filter strips left between burns and streams. Ralston and Hatchell (1971) cite the results of several research studies on the soil loss from burns. These results average approximately 0.2 T/A/Y. Using this value in the FASS procedure, approximately a 30 ppm impact of fire for each of the 20,30,40, and 60-year rotations is computed (Table 2).

One area remains that needs attention - logging and its attendant spur roads and skid trails. The harvest cut in Table 1 and 2 is defined as felling and removing trees which is separate from skid trails and temporary spur roads. Felling and removing trees has a minimal impact on suspended sediment, thus is of no concern in our exercise. However, skid trails and spur roads do yield sediment and the best way to control such soil movement is to water bar and seed them once logging is completed. For water bar guidelines, there are several, but a good brief presentation has been developed by the National Forests in North Carolina Supplement #74 to the U. S. Forest Service Manual (FSM 2482). Seeding with a perennial grass to gain 70 percent ground cover and using water bars should reduce sediment production by 75 percent. The expected results are presented in Table 2. Thus, the total expected suspended sediment resulting from these modifications is less than EPA's proposed standard of 80 ppm as we have assumed it to be applied.

As noted earlier, there are trade-offs between air and water quality. I can visualize the possibility where fire or smoke management may be necessary. If this occurs, then site preparation might need to be KG blade and windrowing, or other intensive site disturbing treatment. For water quality protection, the prepared area would need to be seeded to grass or an annual, for example millet, immediately after clearing to gain at least a 70 percent ground cover. The area should heal in one year and with filter strips should reduce the sediment yield from mechanical site preparation to 44, 29, 22 and 15 ppm for 20,30,40 and 60-year rotations, respectively. With the absence of fire and resultant sediment, such a forest should produce water with approximately 51, 31, 25, and 22 ppm for 20,30,40 and 60-year rotations, respectively, and again meeting EPA's proposed standard.

CONCLUSIONS

Although the above example is hypothetical and uses approximate values, it does provide some useful information. First, the way pine stands are managed has an important impact on water quality. Second, there are trade-offs between air and water quality. Third, foresters must plan management activities throughout a rotation and select the best mix of practices that optimize both timber management and water quality requirements. Fourth, environmental constraints can influence the cost of doing business. Fifth, the application of best available techniques in managing young pine forests may well produce water meeting EPA's proposed standard of 80 ppm.

Finally, this exercise, by the use of approximation procedures, clearly demonstrates the general lack of research on what individual management practices contribute in suspended sediment and other pollutants. Today only a few empirically derived predictive methodologies exist and managers need research based methods to predict the consequences of any and all possible actions if he is to select the best mix of practices to meet water quality, timber and other resources needs. Therefore, much research is badly needed and should be encouraged.

Table 1 Approximate Impacts of Management Activities Upon Average Annual Suspended Sediment - ppm

Forest Management Activity	Rotation-Years			
	20	30	40	60
Mechanical Site Preparation 1/	1109	739	555	370
Fire	55 2/	36 2/	41 3/	27 3/
Thinning	Trace	Trace	Trace	Trace
No Recent Activity	Trace	Trace	Trace	Trace
Harvest Cut	1	1	1	1
Skid Trails	18	11	9	20 5/
Spur Roads 4/	2	1	1	5 5/
Total	1185	788	607	423

1/ Site prepared using KG Blade and windrowing debris, exposing 85% mineral soil.

2/ Two burns during rotation.

3/ Three burns during rotation.

4/ Temporary truck trails abandoned after logging.

5/ Harvesting sawlogs results in more skid trails and spur roads, therefore the approximated impact is higher than in shorter rotations.

Table 2 Approximate Impacts of Water Quality Oriented Management Activities Upon Average Annual Suspended Sediment - ppm

Forest Management Activity	Rotation - Years			
	20	30	40	60
Chopping	5	3	2	2
Fire 1/	31 (3)	28 (4)	31 (6)	31 (9)
Thinning	Trace	Trace	Trace	Trace
No Recent Activity	Trace	Trace	Trace	Trace
Harvest Cut	1	1	1	1
Skid Trails	5	3	2	5
Spur Roads	1	Trace	Trace	1
Total	43	35	36	40

1/ Number of burns in parenthesis.

Figure 1. Land Management - Water Quality Impact Matrix

Mgmt. Activity \ Water Quality Parameter	Turbidity (JTU) and/or Susp. Sediment (mg/1)	Temperature (°C)	Total coliform (organisms/100 ml)	Fecal coliform (organisms/100 ml)	Fecal streptococci (organisms/100 ml)	Specific conductance (mhoo' @ 25 °C)	Total nitrogen (mg/1)	Total PO_4 (mg/1)	Dissolved Oxygen (mg/1)	BOD (mg/1)	Oils (mg/1)	CO_2 (mg/1)	Pesticide/Herbicide (mg/1)	Discharge (cubic meters/sec)	Toxic Salts & metals (mg/1)	Free chlorine (mg/1)	Polychlorinated bi-phony (mg/1)	pH (Std. units)
Timber harvest and physical site prep.	1	2				3	5	9	6	8				7				4
Herbicide and pesticide use		4				2					6		1	3				5
Prescribed burns and wildfire	1	5				2	4		7			8		6				3
Road construction and maintenance	1	2				5			6					3				4
Road oiling											1							
Recreational use & administrative sites	4		2	1	3	5	6	7										
Recreational construction	1					2												
Forest Fertilization						3	1	2						4				
Impoundments	4	1				5	6	7	3					2				
Channelization	1	2																
Grazing	1	2		3	4		5											
Solid waste land fills	4			5		1	2	3		6							7	

Note: Parameters ranked by importance (1= most important)

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